THE USE OF CHARTS ON PRODUCTION WORK.

Abstract of Address presented to the Institution, London Section, by T. G. Rose, M.I.P.E., M.I.Mech.E.

MR. ROSE, in introducing his subject, said : Before we start to talk about these charts I would like to ask you all to bear in mind that a chart is really only a picture ; a picture of certain facts. All of us like different kinds of pictures, and it has been my experience that the personal attitude enters largely into the appreciation of a graphical representation, whatever it may be.

I thought I would give you to-night a general survey of the different types of practical chart that are used in various connections. A number of them are, of course, production charts, but I do not want to thrust any of them upon you for specific purposes. There are many ways of presenting facts by means of graphics, and if you obtain a few new ideas from the slides I show you, you will perhaps widen your knowledge of how you can apply the different type of chart to your own particular problems.

I do not think we need emphasize the fact that it is always easier to visualize facts from a picture than from columns of figures. The production engineer or manager is eternally wrestling with facts and figures, and I must confess that a great deal of my own interest in charts, although it has been going on for a considerable time, developed during the period that I was a production manager. I seemed always to be pursuing all sorts of problems that eternally eluded me. In a sense I developed this charting work, as far as my own Works responsibilities were concerned, because it was the line of least resistance, and I found that by putting the graphical method across these problems it shortened my work.

The opening slides showed how a pictorial representation of facts can be of many different natures. In commenting on a genealogical chart of modern works organization, Mr. Rose said that chaos often existed in organization where there was no proper organization chart. He had seen numbers of cases where muddle was due, to a large extent, to the fact that nobody ever could, or in some cases would, make out a proper chart of duties and responsibilities divided up according to the existing staff. He suggested it was a good plan to make two charts, one of the duties and another showing the

November 13th. Illustrations from author's book, "Business Charts," by courtesy of Sir Isaac Pitman Ltd.

personnel in their present jobs. On comparing the two it could be seen whether all the duties were filled by the existing personnel, and secondly whether the existing personnel were really doing all the duties. When any difficulty arose he emphasized how very much more easily a case could be presented to the head of a concern when illustrated with a small organization chart showing the duties and the people in charge.

One of the greatest mistakes in charting work in business and in production, Mr. Rose said, was that of making the chart " blind "—that is to say, not putting the figures on the sheet.

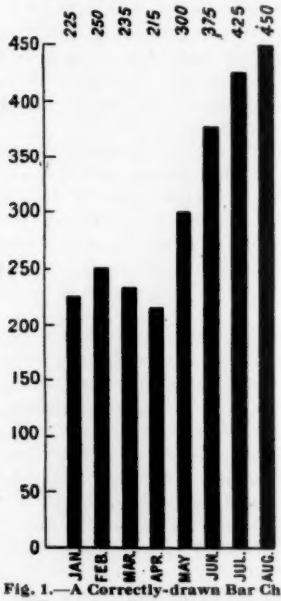

Fig. 1.—A Correctly-drawn Bar Chart.

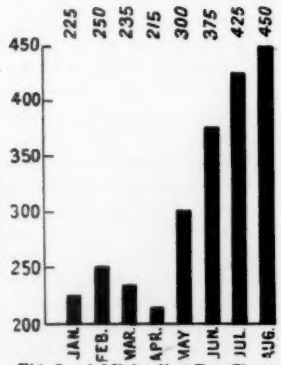

Fig. 2.—A Misleading Bar Chart.

The second mistake was the habit of drawing thin, unimpressive lines, often in different coloured inks, crossing each other intricately so that no clear picture of anything could be obtained. In showing a slide of a " model " for demonstrating facts, the speaker said that these were being more and more used for exhibition work, but that they were not suitable for general use as they were expensive and took a long time to build.

Shop plans were recommended as giving a bird's eye view of roads, gangways, etc., and the shortest distance between one shop and another. For planning work inside the shop foolscap-size shop plans, he said, were extraordinarily useful.

When speaking of bar charts, Mr. Rose stressed the fact that they must always be drawn from zero, as the unwary is tempted to omit the lower section of the bars which is common to all.

He also stressed that they must be solid and decorative, and it was a mistake to speak too slightingly of the advantage of decorative effects.

Divergence charts (the example being a page from an actual overtime and night-shift control), progress charts, compound bar and line charts, quota charts, and zone charts were all explained by Mr. Rose. In commenting on the important " Z " chart he pointed out that it was the most useful chart in business graphics, since it contained the three definite figures which are absolutely necessary for complete knowledge, namely, the current figure, the cumulative figure, and the moving annual total.

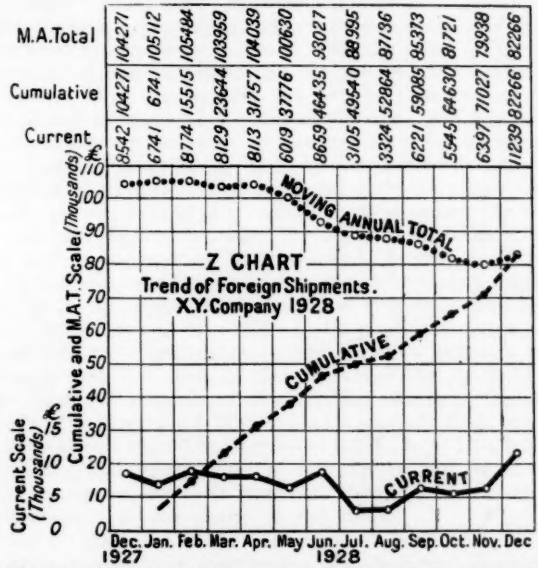

Fig. 3.—The title stands out well when placed as shown in the illustration. Such Z-charts should be clearly titled in order that the reader may immediately know what they are intended to represent.

The double " Z " chart could also be used in practical work as it was a quick method of seeing whether one was keeping outside the danger zones.

After further examples of charts had been shown and fully explained by the lecturer he once more stated how necessary it was

to have clear and simple charts in practical work, and that he himself had found it of great value in production work to put the relative factors that affected production all on the same sheet.

In closing he said that owing to the difficulty with the lantern, he had been unable to go straight ahead quite as he wished, but he hoped that what the members had seen would have shown them the numerous different methods of graphical presentation of facts that were at their disposal, and so help them, perhaps, in their production problems.

Discussion.

MR. W. F. DORMER (Section President): I think we must acknowledge to Mr. Rose that he knows a little about charts and I think he has done very well. He has asked us for some questions, and I know there are one or two of us here who are quite prepared to ask him a few. I feel sure we shall have an interesting discussion.

MR. HAWKINS: Charts are a subject on which Mr. Rose is a "Past Master" and he has not left very much unsaid. He seems to have covered the whole range of different classes of charts and has given a very able exposition of the uses to which they can be put. He has emphasized the fact that you must always show the figures as well as the curve on a chart, in my opinion this wholly depends on the use to which the chart is put. One man is probably quite satisfied with a simple "Bar Chart" showing that the profits are going up and the expenses going down, while another needs the figures in order to keep more closely in touch with the trend. There is one kind of chart which Mr. Rose has not referred to, I refer to the "Colourdex." With this system, ink or pencil are not used, but a lot of coloured celluloid discs, hanging on rows of hooks. Perhaps Mr. Rose will let us know if he has had any experience of this scheme. I should also like Mr. Rose to tell us his experience of the type of production chart which starts off with one colour when the orders are placed, changing to another colour when the material is received, and blacked out when the material is in the shops, etc. Has he any experience of their utility? I have seen them in use in a number of different places but when they have been checked up in the shops you usually find that they are anything from an hour to several days behind. Do production engineers find them useful? Or do they only use them for show purposes and rely on getting a chaser to look up the position of the job in the shop. Has Mr. Rose any experience of exhibiting charts in the shop for the benefit of the foremen? If such charts emanate from one central source they are all right but they must not be kept in a haphazard way, and also the charts must be self-explanatory, in order that everyone can appreciate their meaning. Possibly others can give us their experience of such charts in the shop.

MR. ROSE: As regards the Colourdex—I have heard of it and two or three people have described it. I cannot say, however, that I have had any actual experience of it. As far as the colour charts are concerned, a number of the type I showed ran for two years. Ultimately we improved the organization so that they were not necessary, but they were of practical use at first. Of course, what Mr. Hawkins said about the control or charting systems being kept up-to-date is a very pertinent thing indeed. There is nothing more foolish than complicated systems which are made complicated

because the chief happens to be interested in them ; he may think that they are up-to-date, but they are usually anything from a day to a week behind. It is a mistake to introduce systems of charts which are more than human labour can reasonably keep up ; they must not be complicated to an extent that makes it literally impossible to keep them accurate. As far as charts for the benefit of foremen are concerned, I have found them of great assistance. Charts do appeal to the sporting instinct, and there is no doubt that the best results can be obtained by appealing to the sporting instinct.

THE CHAIRMAN : With regard to the question of putting charts up in works, there was a member from Hans Renold who, when he was giving a paper here, said that he found a definite advantage by the use of charts in the works.

MR. OMEROD : I have taken a great interest in what Mr. Rose has said. Where I have been the great thing is the idea of getting people to understand what is going on. I have, however, seen some works in which charting is carried to an extreme.

MR. HURFORD : Mr. Rose has told us a good deal about charts. What I am more interested in is not charts themselves, but when to chart. The trouble nowadays I find is that people want to chart everything. What does Mr. Rose think are the most important items in the works organization that should be charted ?

MR. ROSE : It is a pleasure to see Mr. Hurford here to-night. He heard, I think, the first lecture I ever gave on charts, a good many years ago. His question as to what to chart is a good one, since there is no doubt that occasions keep on arising when you feel you need a chart, and so you get more and more charts until you become snowed under with them. That is a real danger, yet the opposite extreme of having none is just as bad. There is no doubt that the works manager has a great many responsibilities suitable for charting, and from that point of view I could have given you a talk purely on works control from the works managers' standpoint, with the charts that go with it. Admittedly it is a mistake to try to chart everything, but there are certain basic things which as a works manager you have to do, and those can be reduced probably to something like ten or a dozen charts. Every man who has a responsible job would be wise to spend a certain time a week at a given time (it may only be half an hour) in studying his charts. Many a managing director could save his firm if he would give himself a couple of hours a month thinking hard about the position shown on the charts. A little reflection and meditation in that way, with a determination to jot down the salient points, and take action at once, can be a big help to a busy chief.

MR. SALMON : I am rather interested in the subject of charts, and the one that struck me most was the one that followed the output and payroll comparison moulders' chart, in colour. Mr. Rose spoke about the time of starting these charts or the question of at what stage or how we should chart. Although I may have a hundred different piece parts I have taken the principal ones and have charted them, and I must say I find it of very great value in charting on that principle of the moulders' chart. I have done it for my own benefit, and it has been most useful to me in answering any question at any time of the day. The actual point at issue is that there is a great advantage in it from the firm's point of view ; it does show at a glance, coupled with the figures which you attach to it, the state of affairs. I have adopted three colours, black, red, and green, and am able to chart from twelve to twenty principal piece parts which varied from an output of 200 per day to 1,000 per day. All those items were on one sheet of square paper—I think somewhere in the region of about three feet by two feet, and I can assure you that I derive great advantage from it, which proves that it is well worth the trouble.

MR. ROSE : Mr. Salmon has raised an interesting and important point, and I am glad, because I had overlooked it. It is quite true, as he says, that control can often be obtained by watching just a few parts. I have found that again and again when there is a large quantity of material going through, if you chart the progress of the key parts, the rest will look after themselves to a great extent. As for doing the chart for yourself, I think it is a good thing, within limits. I used, at one time, to have about six pet charts of my own ; my production superintendent used to give me each morning the results of the previous day, and I used to make the charts up myself. It really does not take more than a minute or two, and it drives the facts into one's head very much better. It is a good thing to remember that you can nowadays get octavo, pocket book size, quarto and foolscap charting paper, all in different rulings. There is no need for any charts to be clumsy and unhandy things to use, they can be made as convenient as you like.

MR. HURFORD : I have not heard Mr. Rose refer to the " running average." In cases of big fluctuations, such as value of completed output per employee per week or month, it is difficult to deduce trends unless running averages are used. It is admitted that their uses are limited, and that they should not extend over too long a period, otherwise the curves will not respond to big fluctuations.

MR. ROSE : If you take a running average of an output, the curve shows a kind of tuning-fork vibration effect. I have always been careful about working with averages. I have a suspicion that they tend to give one a wrong impression, and that they are rather tricky things to work with. One of the great dangers in charting

is trying to force a chart to show something for which it is not really designed.

MR. HAWKINS: With reference to the last speaker's remarks in connection with one or two of our statistical records for which we keep charts, we made a standard line by averaging the January figures over a number of years, the February figures over a number of years, and so on each month through the year, thus building up a standard line which we use to compare any particular month's record.

MR. ROSE: That is interesting and very unusual. It is seldom that you can get results going back far enough to do that. So many firms do not keep records for more than two or three years, but undoubtedly a standard or normal line, built up on the lines mentioned, might be of great value.

MR. HAWKINS: In connection with sales where you get a seasonal trend, if you have an average trend over five or six years (if this June is above or below the general average) you get an idea of what is happening. It is a moving annual total possibly of five or six years.

MR. ROSE: To know where the seasonal variation comes in is often of immense importance. One firm told me that they had no seasonal variation at all, but I found that it did exist; there was a primary variation in the spring and a secondary one in the autumn. It proved to be a great help to the production side to know these variations, as they could prepare ahead by the works control chart; they pushed up the stocks and prepared for the seasonal increase of business, and so increased their turnover.

PROFESSOR JEVONS: I should like to ask Mr. Rose whether he has used the moving average to ascertain the trend by taking averages of an equal number of successive dates—that is to say, instead of getting the tuning fork effect, you can take successive averages of twelve months, or successive odd numbers—five, seven, or nine weeks or months. Thus you can get an indication of, say, the trend of labour costs relatively to materials, or apply that method of composing the trend to a number of different figures on the same line chart.

MR. ROSE: Where you get long series of figures, naturally the moving annual total is no use, and there you usually have a moving five-yearly average or perhaps ten-yearly average which have the same object in view, that is, to flatten out the variations. But it seldom occurs in practical business. Twelve months is the period usually taken, and results seldom go back more than two or three years. I have never found anything more useful than the moving annual total method, in my work, but I would like to point out that I am not a mathematician. If I were, I should probably have developed this charting side a good deal further than I have. I

am not afraid to confess that I think I have taken it as far as a practical man wants to, but it can, if desired, be taken a great deal further. I do not say that there is not a field of higher charting work, higher graphics. I know there is. Statisticians, for instance, use a great field of such methods, into which I shall never enter. But that is a special field of its own, and for practical production purposes, much can be done with what I have tried to give you to-night, the elementary principles.

MR. H. E. WEATHERLEY: I have the pleasure of proposing a vote of thanks to our lecturer, Mr. Rose. Before doing so, Mr. Rose, I should like first to congratulate you upon your election this evening as Vice-President of the London Section, and I am sure you will find it a very interesting office. Let me now thank you very much for the very interesting talk you have given. It has been most instructive from beginning to end. Speaking personally, I have been particularly struck by the various charts mentioned, and shall undoubtedly adopt one or two, though I think the one I shall take most notice of is the one Mr. Hawkins referred to: directors' rising profits and declining expenses. In conclusion I would say that we do appreciate very much the time you have given, and I ask members to show their appreciation in the usual manner.

The vote of thanks was cordially adopted.

COLD METAL WORKING.

Paper presented to the Institution, Coventry Section, by H. G. Povey, M.I.P.E.

The Advantages of the Cold Method.

UNDOUBTEDLY, cold metal working is an important link of all mass production methods. Firstly, the enormous saving on material; the speed of production, as the cold process lends itself readily to mechanical means of feeding, etc., the assurance that your article is manufactured with the most suitable material as it is essential to have rigid control and inspection of all material used in this process.

An important operation on cold metal working, is the art of cold heading, used for the manufacture of all kinds of bolts and nuts for the better class trades, also for the cheaper screws and pins used in the stove and such like manufactures. The difficulty in the past with this machine was lack of a supply of material that would head satisfactorily or, after heading, give the requisite tensile, etc.

As I mentioned previously, the whole art of cold metal working lies in suitable material, but to-day, with the great strides made by the material suppliers, who can, with their range of alloys, supply materials for all purposes, this difficulty no longer exists and hence the phenomenal development of the cold header and other cold metal working machines. There is nothing new in the operation of cold heading as it was one of the first Birmingham trades; I should say, known before the advent of the capstan lathe, when it was used for all classes of nail production and cheap casting-in screws, etc. We are now realizing that the bolt made on the cold header with a correct control of material, suitably heat treated, is a better job as regards tensile than any bolt that we could produce from the bar. This is the direct opposite to the opinion prevailing a few years ago, in this country at any rate. The success of the bolt is due to the fact that we have a perfect grain flow, whereas on the bar-made bolt the grain must always be in one direction. Headers are built to give either one, two, or three blows and may be equipped with either solid dies, or open dies, known more commonly as SPLIT DIE MACHINES.

The solid die machine is used for all the better class work, as there are no fins left from the tools, but one is limited on the solid die machine to the length of shank compared with the diameter, which is approximately 8 : 1, which means a half-inch bolt can be

produced on the solid die machine up to four-inch length of shank. The limit on this length of shank on the solid die machine is caused through the difficulty of extraction and, of course, may be overcome by the introduction of a little taper into the die. Therefore, the solid die machine is limited to all the reasonably short work. The split die machines are made to handle any length. You can have the automatic machine running from the coil up to a length of approximately 16 diameters. Then, you may also use the ROD HEADER, where the blanks are previously cut off to length inserted into the header either by hand or by auto feed, and the requisite heading operation performed. Such a machine would be used for heading special long bolts, making spokes and such-like pieces.

As regards actual production times on the cold header on single blow work, on alloy steels, machines are built to-day by the Waterbury Farrel Foundry and Machine Co., to produce 25[illegible] pieces per minute, up to $\frac{3}{8}$-inch diameter, shank, and one inch long. With regard to double blow work, the same company produce a $\frac{3}{8}$-inch diameter bolt, six inches under the head, at 95 pieces per minute On the half-inch machine, we produce a six inch blank at 80 pieces per minute. Taking the extreme case of cold heading of one inch diameter shank up to $8\frac{1}{2}$ inches long, the production is 45 per minute. These figures are the attraction of cold heading.

Comparison with Turning.

We must all realize the foregoing production figures. It makes any other kind of production look pretty slow. As a comparison, I will put forward what I believe to be the fastest metal mover in the whole trade. This machine is little known and only just developed. It is the single spindle automatic designed and built by the well known firm of Berlin machine tool makers, Loewe-Gesfurel, A.-G., and is capable of putting up some startling production times. The headstock of this machine is built on the slope, which makes chip clearance and bar feeding a simple matter. The tool head takes the form of a huge die head, the tools being shaped to the contour of the piece to be turned and, even on simple reduction work such as a large diameter bolt, say 3/4-inch diameter by six or seven inches long, the four tools come in simultaneously and reduce the shank at one movement. This machine has many attractive features of production ; universal cams, elimination of all tool spring, no levers or joints of any description interposing between the cam and the various tools. The machine is arranged to run right from black stock, fully automatic, any variation in the size of the stock being taken care of mechanically. The machine is built to take $2\frac{3}{4}$-inch diameter bars with a turning capacity up to 10 inches long. The locking and driving mechanisms of this machine, when on maximum cuts, is designed and built to transmit 40 H.P.

Taking the case of a 45 mm., rough bar in the machine, it will turn a bolt 30 mm., diameter shank, 170 mm., under the head and part off complete 82 pieces per hour. On a bar 18 mm., diameter cutting a bolt 10 mm., diameter, 104 under the head including parting off, the production is 128 pieces per hour. Compare this latter example with the speed of the cold header and we realize the advantages of cold heading. I would make it quite clear that this machine is used on all kinds of gear box layshafts and similar work totally unsuited to cold heading. Fortunately, we have slides available of this machine and can discuss any details if anyone would so desire.

Thread Rolling.

To show development on the thread roller, the Waterbury Company now build a thread roller with a capacity of 1½-inch diameter thread × 4½-inch length of thread, with a production of 30 to 35 pieces per minute, this machine weighing 26 tons, and used for all kinds of bolts for the construction of the underground tubes and railroad tracks. It is rather interesting to note that this machine has been built to supply a demand for special analysis bolts of unusual size and strength, which cannot be economically produced by any other means. In other words, the alloy bolts which can be successfully threaded on this machine, could not be commercially threaded by the cutting principle, due, of course, to the toughness of the alloy. This is the first fact to remember, that a thread produced by the rolling process exceeds in strength any similar bolt produced by the cut thread process. By the way, this machine is used also for rolling all kinds of hot work, when, of course, the capacity can be still further increased. As a matter of fact, up to 2½-inch diameter bolts are rolled hot. The thread roller is simply a means of displacing material—no cutting whatever takes place. Two flat dies have the thread contour milled in at the helix angle and the bolt is rolled between the dies and displaced to fill in the form of thread required.

Another instance showing the wide use of the thread rolling machine is that of serrating armature shafts of electric starters and dynamos. The alternative method of production would be pulling the shafts through the broach which would take approximately one minute per shaft. The hand feed thread roller equipped with simple serrated dies performs the operation at a speed of 40 per minute, a substantial saving on production.

The thread rolling machine is built either as a hand feed machine or hopper feed machine, depending upon the production and shape of the piece to be threaded ; all large diameter bolts, tie rods, and special tap blanks, are generally threaded with the use of the ordinary hand feed mechanism. The thread roller run as a hand feed

machine is still fast, as an ordinary operator, irrespective of the size of the machine, will feed at 40 to 60 pieces per minute. When equipped with Hopper feed for a special job requiring large numbers, we have a machine of wonderful capabilities as regards production times. Taking the case of threading small typewriter screws up to, say, $\frac{3}{32}$-inch diameter thread, after producing these blanks on the header, we fill the hopper on the auto feed threader and automatically feed to the dies, roll thread, and eject at a speed of 150 per minute, with no tool trouble, since after the dies are once set, no alteration can take place in the tools so long as the blank size is properly controlled. Taking a more suitable case for the car trade, we can thread half-inch bolts × four-inch length of thread, at 60 per minute, this time could be equalled on the hand feed machine but the saving is on the number of operators required, as one operator would take care of several auto machines.

On the production of all kinds of hot bolts for the railroad wagon companies, imagine the enormous saving on the thread roller against the ordinary screwing machine. Even one $\frac{5}{8}$-inch thread roller producing 50 blanks per minute with one operator would do the work of a large department of screwing machines and operators with remarkably low tool and depreciation costs, due to the simple design of the modern thread roller. This machine is also utilized for all kinds of, shall we say, milling operations. Where one needs a flat, milled in a particular spot on a piece, the reciprocating side of the roller is equipped with a flat broach and the pieces are automatically fed into the roller, flatted and ejected. The roller is also utilized for all kinds of sizing. In this case we use ground thread dies for transmitting the grinding marks on the pieces to be sized. The process is also suitable for all kinds of knurling, and serrating of cylindrical pieces.

It is certainly a fallacy to link up the thread roller with cheap or common work. To-day dies can be obtained which have been corrected after hardening. These dies correctly set in a modern machine, the operator using correct blanks made of the right material, do not fail to obtain a perfect thread. It is impossible to roll a bad thread under these conditions. It is certainly a good physical test for material to pass it through the thread roller as it opens up any flaw or imperfections. Always remember with roll thread work that one has no pitch errors, as the pitch is fixed according to the accuracy of the thread roll dies.

Trimming.

We have considered the header and thread roller on bolt production. We must now take the remaining operation which is the trimming of the head of the blank into the hexagon form. As we cannot produce the hexagon form accurate enough for first class

work on the heading machine we revert to the TRIMMING MACHINE for automatically trimming the previously headed bolts into the hexagon form. This machine takes the blanks from the hopper and trims the flats on the head, concentric with the shank, at a speed of 120 per minute, taking the case of a $\frac{3}{8}$-inch bolt.

Following on with production times, the half-inch bolt may be automatically trimmed at 80 pieces per minute. These machines are in common use up to $\frac{3}{4}$-inch capacity. Recently this machine has been developed to incorporate another operation; when producing a cold headed bolt for thread roll purposes, as the majority of bolts have a plain portion under the head, it is necessary to obtain a reduction on the shank to allow for thread rolling. This reduction takes the form of what you would term a wire drawing operation or extrusion and is done simultaneously with the trimming of the head into the hexagon.

Touching on the question of the manufacture of hexagon and square nuts by the cold process, a sturdy horizontal press is arranged with an automatic roll feed and straightener; the strip is shaped in the case of the hexagon nut, and pierced simultaneously, and by this method $\frac{3}{8}$-inch Whitworth nuts are made at the rate of 60 per minute, these nuts being perfect as regards sizes across flats, thickness, etc., and equal from the utility point of view, to the bar made nut.

Power Press.

I suppose we must include in this paper the power press, the most commonly used machine on all classes of metal forming, etc. Although the tendency has been to improve the tools and tool design to keep pace with the development of production, rapid strides have also been made on the press itself, one most interesting press being the undercranked press, designed and built by the Henry & Wright Manufacturing Company of Hartford, Conn., United States America. This machine incorporates some wonderful features. The underslung crank is connected to a bottom cross head which, in turn, is linked up with the four guide posts situated around the tools. The posts give a direct down pull to the punch pad, pulling the tool absolutely central into the die with no tendency to side track or put any side pressure on the tools whatever. This form of construction gives one a machine with a very low centre of gravity and a very open tool space for setting purposes. On all descriptions of blanking work this machine puts up some phenomenal speeds, the 10 tons machine running at 350 strokes per minute. Even on the larger sizes of 100 tons, they run continuously at 120 strokes per minute. This machine is built right up to 150 tons pressure. There are now other makes of four-post presses, but these are not underslung. The

development in this type of press combined with the improvement in tool design constantly taking place enables an accuracy and economy to be obtained which hitherto was considered impossible. The stu:dy example of this type of press is the WATERBURY FOUR POSTER, built in sizes from 20 up to 120 tons capacity. This press, when built to this design, with the crank and operating mechanism arranged overhead, has among other advantages the feature of an adjustable bearing above and below the tool line. In other words, four guide bars are running in adjustable bearings housed in the box form of main press body.

By the courtesy of Messrs. Fisher & Ludlow (1920), Ltd., and with the able assistance of Mr. Shaw, who, by the way, is one of our members, I shall be able to throw slides showing production on car bodies and other car parts. As the slides will show, a great deal of pluck is necessary to install such a plant in this country. We will discuss the Fisher & Ludlow plant later when we throw the slides on the screen.

Cold metal working covers such a range of machinery and processes such as the production of ordinary ferrous and non-ferrous tubes, and wire drawing, where one starts with $\frac{5}{16}$-inch diameter wire at one end of the machine and finishes up the far end of the bench with wire as fine as .060-inch, this size wire coming off at well over 3,000 feet per minute, that it is impossible to incorporate all in an ordinary paper. Therefore, I have enlarged as much as possible on the machines applicable to the car and Midland trades, of a repetition character. Naturally, design must link up with this method of manufacture. I have in mind the design of a well-known car wheel. The spokes are so designed to eliminate screwing with subsequent hand assembling and costly truing operations, with a special double end heading machine equipped with simple transfer feed, the complete spoke headed both ends with the heads set to the required angle, may be produced automatically from coil wire. This design of spoke enables the wheel to be assembled on the automatic dial feed welder and subsequently trued by a fast process operation.

Nothing known can equal the cold method of producing square or hexagon blind holes. An excess of material is left on the outside diameter and the piece is closed over a shaped pilot by means of a taper drawing die. Another interesting press job : the making of collapsible tubes used as containers for grease, glue, etc. These tubes are squirted in a power press 35 to 40 pieces per minute, after which they are passed along to the special lathe for trimming and thread rolling. The screw caps, by the way, for these particular tubes, are made cold and completed by means of a special set of tools in the power press.

Discussion.

MR. DRANE : How do you ensure that the shank of the bolt shall be concentric with the head ? Also, to what degree of accuracy can the diameter be guaranteed ? I assume they are controlled as the diameter of the shank must have some bearing on the ultimate thread produced. Have you had any experience with thread rolling multi starts ? I think you have only spoken about Whitworth threads. What is the nearest to a square thread which you can roll cold ? Will you tell us something about the life of the dies. I should also like to know about the adjustment of the dies.

MR. POVEY : In regard to keeping the shank concentric with the head on the heading machine, if it is a hexagon bolt of course we afterwards trim and in the trimming tools, naturally, the shank is held concentric with the head trimming die. You locate from the shank. When you are cold heading your circular blank, before trimming, if you do not watch what you are doing, when you have trimmed you will not have the shank concentric with the chamfer. As regards the accuracy of the shank, this is absolutely dependent on the bore of the die. As the die wears, naturally the shank increases in size. Approximately 15,000 blanks in a solid die would open up about .0005-inch. On thread rolling you are absolutely limited as regards blank size, which must be correct. You can roll multi-start threads quite well. I have had no experience with rolled square threads but I do not see why they should not be rolled. It is purely dependent on the pitch, form, etc. As regards the life of the dies, on an ordinary small bolt die cost is neglibigle ; something in the neighbourhood of 10,000 gross may be produced from one pair of dies. The dies are made of an alloy but high speed steel is now being used for thread roll dies. The trouble is that they do not stand up as long as the alloy steel die but can be re-lapped periodically to maintain the form. In regard to the adjustment of the die, you have full control on the machine. The chief thing is the diameter of the blank before rolling.

MR. NEWBOLD : Would there be any proportion as to the reduction on the outside diameter according to the thread which is to be produced. If so, can you give me that proportion. Regarding the volume of the head, I assume you take this value, calculate the length of the wire to be a shade more than the volume of the head, so that you would be somewhere near the mark on the first setting of the machine to get a perfect head.

MR. POVEY : You are quite right there.

MR. NEWBOLD : On the Loewe special bar automatic illustrated, if you have plain turning when the tool has come up in direct contact, how is a thread put on ? With regard to the power press shown equipped with marquette cushions, on drawing operations

is not there a point here which is very weak for development? If you have a draw and you want a flat bottom I think you will find that you cannot get the pressure on this process as you would obtain on a good solid base press.

MR. POVEY: If you take soft iron and thread roll it, you are going to compress it as you roll up. On carbon steel for tapped blanks your theoretical size is the outside diameter of the thread less one side depth, which gives you the correct thread rolling blank size. On carbon steel this is correct. With iron you are compressing as you go up, therefore, an allowance of a few thousandths per $\frac{1}{4}$-inch of diameter must be allowed to compensate for the compression. If you are working on very close limits, you cannot get a constant blank size for all materials. Referring to the question of the volume of the head you can soon get the number of diameters in any particular head when producing on the header as you increase your feed until the die is completely filled. The heading man can tell by looking at the head. A $\frac{3}{8}$-inch Whitworth blank die contains about $4\frac{1}{2}$ diameters of shank. As regards press tools, your idea is that if you have a job with a reasonably deep draw you get a much better face from the solid base press. I do not think so, as the blanks should follow the punch. On the pneumatic cushions you can get almost any pressure you desire—about 200 tons.

MR. R. H. JONES: I would like to say a few words about this question of the marquette cushions used on a press. Actually, the marquette is only used for extracting. When you think of a tonneau, the back panel of the car, the bottom of the die of which is the shape of the window and door, this is a great heavy piece of metal. For instance, in the Morris Cowley, the bottom of the die which is false, is somewhere in the neighbourhood of two tons. You cannot extract it with springs, neither can you extract it from the crankshaft, and this is where a marquette is used to advantage. There are occasions when they use it for raising the bottom, but it is unnecessary. You would get a much better job from the solid bottom press than from the press equipped with pneumatic cushions. In a motor car body there is not a deep pressing at all. You get far more interesting press work in other trades than you get in the motor car body, but it is so large that it appeals to people.

MR. POVEY: When you are drawing on a single action press you reverse your operation. Your punch is supported on the pneumatic cushion and the die suspended on the ram. This enables you to do a double action job on a single action press.

MR. NEWBOLD: That is the only instance where the marquette has an advantage. Even then the tools are 75 per cent. more expensive.

MR. POVEY: With regard to Mr. Newbold's question regarding the threading of a piece on the Loewe automatic, the machine may

be equipped with a four-hole turret, and when your four turning tools are withdrawn you can come in with your turret and do the various operations the same as on an ordinary automatic turret lathe.

MR. MACNAB: You have made reference to steel manufacturers getting down to accurate size material, and it also struck me that in the $4\frac{1}{2}$ diameters upset you are rather, to my way of thinking, severe, inasmuch as we accept three diameters upset as maximum. If you make $4\frac{1}{2}$ diameters upset, what disintegration would you get in the head? It appears to me that the material must be very good to stand this punishment. In regard to the material for the cold heading tools, it would be rather interesting if you could give us some formula as regards the composition of material for these tools. At what rate would be the growth of the bore over a quantity? You also mentioned the taper on the bore. In centreless grinding headed pieces, it is important to keep the thing absolutely parallel—not the slightest projection of any description—because that is fatal. I was also interested in the Loewe bar machine. I should have thought that some elaborate method of upsetting would have beaten this machine. It would be rather interesting to have some data regarding that. Compared with upsetting, I thought the production from the machine mentioned was very poor, considering the loss of material in producing the components.

MR. POVEY: I think you will quite safely obtain material to stand three diameters comfortably, but incidentally, the right way is to cut down the amount of work in the head between your annealing operations and that is the reason why the triple blow header is not popular. No trouble should be experienced from crystallisation on putting $4\frac{1}{2}$ diameters into the head with two blows, as I have seen a German concern putting up eight diameters with one blow which, of course, would produce crystallisation in the head, but this would take place towards the top of the blank, therefore not effecting the strength of the head. In regard to the comparison when using the Loewe bar automatic with the cold header on an ordinary plain bolt $1\frac{1}{2}$-inch diameter head shanked down to $\frac{3}{4}$-inch diameter, six inches long, it would not be a cold heading job, therefore the comparison would be unfair. This machine would show a great saving on costs, as you could run on black stock instead of the ordinary bright finish required on most autos.

MR. MACNAB: The saving of material is a considerable item if it comes to high tensile bolts. Cold heading on most production lines has, of course, got everything beaten.

MR. CROWTHER: The rolling of serrations is a rather interesting subject. It is, of course, of vital importance that the diameter of the material be correct. I should like to know what the shape of the rolling tool is in relation to the shape of the serrations. Is it the same and if not, what variation in shape is found necessary?

An analogy would appear to be the condition of hobbing a worm wheel in a milling machine without a preliminary gashing.

MR. POVEY : Your serrations on the die are naturally different from the finished spline as you generate an involute on your blank when rolling. If the material is a little soft it is equivalent to running on a smaller blank.

MR. LESLIE WILEY : In regard to the production of Allen set screws, I think the best way to produce them would be to thread roll after the hexagon is formed in the head. Is there any difference in thread rolling, and would it close the hexagon down somewhat ?

MR. POVEY : Yes, that is the snag on the job. You cannot thread roll the Allen set screw without closing in the hexagon.

MR. AIERS : In connection with the thread rolling, you mention the difficulty of obtaining material which would cold work. The range of alloys for cold heading is excellent. What troubles did you have with the original steels, and why would they not cold work ? As far as I know, the various alloys are only making it worse for cold heading. You also state that many alloys are now available. Will you tell us what these are, and if you have tried stainless steel ? You stated that some of the production figures for cold heading were very high and said that as regards ordinary bar material, the figures given do not appear high, but on cold heading you have definitely spoiled the metal and it must be heat treated. Therefore, the time for heat treatment should be added. You also mentioned that the cold headed material was stronger. Agreed. By every degree of strength you have definitely added brittleness as well. You could, if you liked, say you had increased the strength from 40 to 80 tons, but only at the expense of reducing the elasticity. As regards splining, you mentioned that you could roll serrations, but as already mentioned you cannot do it where you are going to make interchangeable parts, as you get a variation in the number of serrations required up to plus or minus one. I should have liked you to have dealt with cold working of strip material. If you do not get it heat treated and you have it enamelled the heat is sufficient to cause crystallisation and all your parts will fracture. I think it is the heat treatment which is important in any cold working.

MR. POVEY : As regards strip material, it is really lack of testing of material before the material is used in production. On a shipment of strip material you can take a piece about 4-inch square from a number of the strips and draw it with a constant shaped punch until the draw fractures. Immediately the fracture occurs you measure the depth of draw, thereby getting the drawing value of each particular strip. This is, of course, the Erichsen sheet metal test. It is a very simple test and the depth of draw may be measured in situ on the machine or independent of the machine. If you get

a strip that goes through the drawing or bending process satisfactorily and take the Erichsen value you will find that any material giving that Erichsen value will do the same operation without fracture.

MR. LESLIE WILEY : Regarding the accuracy of thread rolling, I understand that a certain manufacturer of micrometers used a spindle that was threaded by means of a thread roller.

MR. POVEY : Regarding Mr. Wiley's query of thread rolling micrometer spindles, the Reed & Prentice Co., of America, who turn out a good accurate micrometer, have thread rolled the spindles for a number of years.

MR. HUGHES : Regarding electrically formed valves, we have had some unfortunate experiences with same. We had quite an epidemic of valve failures and had one sectioned up, and immediately scrapped all the valves we had electrically forged as they would not stand up to the conditions. On aero engine work we use special alloy steels and all bolts are very highly stressed. When you buy a bar made bolt of good manufacture, you can depend on the grade of the steel being such that the shear and tensile are going to be the same after the bolt is made. With a headed up bolt you cannot be sure of that as when it is headed up it is pushed beyond its yield point.

MR. POVEY : On valves, in my opinion, you cannot touch electric forging as it eliminates considerable machining or finishing times. I am not surprised at Mr. Hughes' experiences. As a matter of fact it is the experience of early cold heading over again. With some of the alloy steels the temperature of forging has a very narrow margin and therefore you must have a method of controlling temperature closely and automatically, taking away the human element, I think I am right in saying that the receding anvil will do that, thereby controlling the temperature by means of the pressure on the piece being heated. In other words, the heat at which you forge is controlled solely by the pressure on the tools. I do not think any other system touches the receding anvil on this point as if one electrical forging is bad they are all bad. Make a good forging and they are all constant. As regards the cold headed bolt on aero engine work, there are firms in the States laid out for nothing else but cold process bolts and I know that one large American firm advertises the fact that they supply to the aero engine trade. I think it is harder to make a good sound bolt by the cold headed method, as it involves much control of material and heat treatment but it can be done. I think we have a lot to learn from the Americans as regards controlling material and mass production hardness testing.

MR. MACNAB : In the first installation of these electrical forging machines in this country I think a great deal of the trouble was caused in the pulsations of the pump as the frequencies of the pump caused a certain amount of surface disintegration of the valve head. Now I think it has been more or less overcome.

The meeting concluded with a vote of thanks to Mr. Povey.